NASA TECHNICAL MEMORANDUM NASA TM-76151

THE BEHAVIOR OF FATTY ACIDS IN THE BLOOD PLASMA OF MONKEYS FOLLOWING EXPOSURE TO SHORT TERM STRESSES

M. L. Michailov, U. Gnuechtel, St. Nitschkoff, R. Baumann and G. Gnauck

(NASA-TM-76151) THE BEHAVIOR OF FATTY ACIDS IN THE BLOOD PLASMA OF MONKEYS FOLLOWING EXPOSURE TO SHORT TERM STRESSES (National Aeronautics and Space Administration) 8 p
HC A02/MF A01 CSCL 06P G3/52
N80-27079
Unclas
27954

Translation of "Verhalten von Fettsäuren im Blutplasma von Affen nach Einwirkung kurzfristiger Stressoren," Acta Biologica et Medica Germanica (East Germany), Bol. 32, 1974, pp 675-680.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 MAY 1980

STANDARD TITLE PAGE

1. Report No. NASA TM-76151	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE BEHAVIOR OF FATTY ACIDS IN THE BLOOD PLASMA OF MONKEYS FOLLOWING EXPOSURE TO SHORT TERM STRESSES		5. Report Date May 1980
		6. Performing Organization Code
7. Author(s) M. L. Michailov, U. Gnuechtel, St. Nitschkoff, R. Baumann and G. Gnauck		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No.
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Verhalten von Fettsäuren im Blutplasma von Affen nach Einwirkung kurzfristiger Stressoren," Acta Biologica et Medica Germanica (East Germany), Bol. 32, 1974, pp 675-680.

16. Abstract

Monkeys exposed to short term stresses (immobilization, jealousy) were found to develop hyperlipacidemia with a rise in concentration of unsaturated fatty acids in blood plasma, especially of oleic acid, and a relative decrease of saturated free fatty acids, chiefly of palmitinic acid. This finding was more pronounced under immobilization stress than in the jealousy situation. Meanwhile, the composition of triglycerides did not change essentially under the conditions used.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified-Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	8	

NASA-HQ

THE BEHAVIOR OF FATTY ACIDS IN THE BLOOD PLASMA OF MONKEYS FOLLOWING EXPOSURE TO SHORT TERM STRESSES

M. L. Michailov, U. Gnuechtel, St. Nitschoff, R. Baumann and G. Gnauck
Central Institute for Cardiac and Circulatory Regulation Research of the East German Academy of Sciences, 1115 Berlin-Buch, Wilthergstrasse 50

A series of modifications in metabolic parameters may be assessed in the animal and human organism as the function of a stress condition. Stress-sensitive animals present metabolic shifts as an emergency reaction to conflict situations in the environment that are linked with negative emotions and induce excessive tension in the central nervous system. Monkeys in particular are quick to react in this respect and this is especially true of anything that disturbs their social relationships [1]. In them as in humans, emotional excitation is accompanied by a distinct fluctuation in various physiological functions. Such modifications may assume larger proportions in monkeys than in people. /675*

Thus we were interested in finding out to what extent fat metabolism and the dynamics of free fatty acids in the blood plasma are modified by short term psychoneural overload.

Method

For the experiment we used four baboons (papio hamadryas), two males designated No. 1 and No. 2 and two females designated No. 3 and No. 4, age range 6-8 years. The males showed an average weight of 22.7 kg and the females 10.4 kg. Feeding and living conditions were identical for all. Following a twelve hour night fast we conducted the following experiments in the morning. /676

The females were fastened to a board in a supine position for 20 minutes [2] in a way that made it possible for them to see monkeys moving about freely. On the other hand the males were alternately isolated from their herd and saw their mates in the company of other males for 20 minutes. Both procedures unleashed strong emotional reactions expressed in threatening, aggressive or defensive behavior.

Before and after the experiment arterial pressure was measured by the Riva Rocci

---

* Numbers in the margin indicate pagination in the foreign text.

TABLE 1. TOTAL FATTY ACIDS (MICROMOLES/LITER) AND VALUES FOR INDIVIDUAL FATTY ACIDS (%) IN BLOOD PLASMA OF MONKEYS BEFORE AND AFTER EFFECT OF STRESS FACTORS

a	Nr. 1		Nr. 2		Nr. 3		Nr. 4	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
gesamte FFS	803	410	616	712	578	615	306	474
gesättigte FFS b								
C_{10}	1,0	1,2	0,8	0,8	0,5	0,6	0,5	0,7
C_{13}	1,7	0,6	0,6	1,1	0,1	0,2	0,1	0,2
C_{14}	2,6	2,1	2,1	2,6	2,4	2,2	2,4	2,1
C_{15}	1,7	1,3	0,7	0,5	0,9	0,5	0,9	0,6
C_{16}	34,4	20,1	31,8	33,0	31,1	24,3	40,0	35,5
C_{17}	1,1	1,0	1,6	1,1	0,1	1,2	0,3	0,4
C_{18}	9,8	6,1	8,2	8,3	11,1	11,0	8,0	7,1
C_{20}	Sp.	0,6	0,7		1,5	1,2		
	52,3	24,0	40,8	48,0	51,3	41,2	53,4	46,4
ungesättigte FFS c								
$C_{12:1}$	0,6		0,4	0,4	0,1	0,2	0,1	0,2
$C_{14:1}$	3,8		0,2	0,8	0,3	0,3	0,1	0,2
$C_{16:1}$	3,1	4,0	5,6	5,1	2,0	4,3	3,8	5,1
$C_{18:1}$	13,7	20,6	21,9	23,3	27,8	30,7	20,9	20,7
$C_{18:2}$	6,3	13,5	10,1	10,5	12,5	11,7	15,6	13,8
$C_{18:3}$	0,4	3,5	1,6	0,6	2,6	2,9	0,8	1,0
$C_{20:4}$	10,8	6,8	10,8	11,5	3,7	8,7	5,1	6,5
	47,7	57,4	50,5	52,0	48,7	58,8	46,6	53,6

Key: a. Total fatty acids.
b. Saturated fatty acids.
c. Unsaturated fatty acids.

method and blood was taken from the vena cubitalis. Chloroform-methanol was used to extract lipids from the plasma and these were then fractioned by TLC. The fatty acids were methylated with 5% HCl-methanol and the triglyceride fatty acids transformed with 0.25 N Na-methylate for gas chromatographic analysis. The equipment used for this purpose was the GHCF 18 3 gas chromatograph (State owned Chromatrom, Berlin); columns 2m x 4mm filled with 10% DEGS on 100-120 mesh Gaschrom; column temperature 190°C (isotherm); carrier gas purest nitrogen, 2.5 liters/hr; fuel: hydrogen = 1.5 liters per hour, air = 25 liters/hr.

Total fatty acids were studied colorimetrically by the Duncombe method [4].

The Fermognost test determined blood glucose concentrations enzymatically.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 2. ESTERIFIED FATTY ACIDS OF TRIGLYCERIDES (%) IN BLOOD PLASMA OF MONKEYS BEFORE AND AFTER EFFECT OF STRESS FACTORS

	Nr. 1		Nr. 2		Nr. 3		Nr. 4	
a	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
gesättigte Fettsäuren								
C_{12}	0,3	0,1	0,2	0,2	0,5	0,[illegible]	0,1	0,[illegible]
C_{13}	0,4	0,1	0,2	0,1	0,1	0,1	0,3	0,2
C_{14}	1,0	1,3	1,3	1,2	1,2	1,0	1,0	2,4
C_{15}	0,7	0,4	0,4	0,3	0,3	1,4	0,2	1,7
C_{16}	34,2	27,7	32,1	36,7	35,1	38,7	33,0	37,5
C_{17}	1,2	1,4	0,7	1,4	0,6	1,2	2,2	1,8
C_{18}	4,0	6,8	1,8	5,2	5,2	5,8	5,0	5,5
C_{20}	0,7	0,5	1,0	0,3	1,2	2,0	0,6	3,5
	44,2	38,0	41,5	48,1	44,2	51,4	42,4	52,7
ungesättigte Fettsäuren								
$C_{12:1}$ b	0,4		0,1		1,0	0,2	0,1	
$C_{14:1}$	0,2	0,2	0,3		0,1	0,3	0,4	0,0
$C_{16:1}$	1,7	3,8	4,3	3,4	4,2	4,8	2,6	4,1
$C_{18:1}$	29,6	39,7	31,7	32,7	36,3	29,0	38,3	21,4
$C_{18:2}$	12,8	17,5	14,7	11,[illegible]	10,6	11,2	13,2	19,0
$C_{18:3}$	[illegible],5	0,8	3,1	0,6	1,4	0,8	1,0	0,7
$C_{20:4}$	6,0	[illegible]	4,3	6,4	2,2	2,3	2,0	1,2
	55,8	62,0	58,5	54,8	55,8	48,6	57,6	47,3

Key: a. Saturated fatty acids.
b. Unsaturated fatty acids.

Results

In the males arterial pressure rose during the jealousy conflict from an average 143/93 mm Hg to 167/101 mm Hg and systolically, with p = 1%, was higher than initially. On the other hand in the females the BP following short term immobilization was not higher than initially: 129/80 compared with initial 119/79.

Only No. 3 and No. 4 presented a hyperglycemic reaction following immobilization. Their blood glucose concentration rose from 108 $\pm$ 24.7 to 201 $\pm$ 29.6 mg/100 ml.

As we see from Table 1, in baboons No. 2, 3 and 4 the effect of stress was a distinct rise in total fatty acid concentration, while for No. 1 it went down.

The saturated fatty acids showed a moderate decline involving especially the predominating palmitinic acid (C_{16}).

The unsaturated fatty acids attract attention by the percentual increase in oleic acid concentration. The polyene fatty acids showed different deviations without any substantial change in the overall sum.

In the case of the esterified trigylceride fatty acids (Table 2) there were only low grade abnormalities. In the monkeys subjected to immobilization stress there was a tendency towards a higher degree of saturation and also towards increased palminitic acid concentration.

Discussion /677

The results show clearer metabolic changes in the case of immobilization stress than for the jealousy situation. In contrast to the BP pattern we are dealing here with hyperlipacidemia and hyperglycemia. Moreover there are abnormalities in the composition of the fatty acids characterized by a decrease in saturated fatty acids and increased concentration of the unsaturated ones. These shifts may be interpreted as the consequence of a neurohumoral reaction induced by an intensified functional state of the central nervous system which is affected by the changed environment. Baumann et al. [5] postulate alterations in two cerebrovisceral systems when there is acute or chronic stress: (1) in the neocortical-limbic-hypothalamic-sympathetic system and (2) in the neocortical-limbic-hypophyseal - corticosuprarenal autonomous system, which process afferent information and also include fat metabolism via relevant modifications in the neurohumoral factors. This is accompanied by increased activity or greater /678 concentration of various physiological substances, as for example ACTH, steroids or catecholamine (counterregulatory for insulin secretion), which play an important part in the organism's defense system. Due to a beneficial adaptive effect of the sympathetic nervous system changes occur in liver glycogen, blood sugar concentration and lipolysis. Increased lipolysis has also been noted for humans under emotional stress [5, 7]. This is emphasized by studies that demonstrate an increase of the catecholamine in the plasma, especially clear in the case of noradrenaline [5, 8]. Glycolysis in the cell plasma as well as the respiration chain of the mitochondria respond to an increase in energy consumption characteristically by heightened performance of glycolysis and oxidative metabolism. At the same time glycogen phosphorylase and phosphofructinase function as the chief control elements for carbohydrate decomposition. A result of greater catecholamine concentration is the stimulation of cyclic AMP and a simultaneous occurrence of glykogenolysis and enhanced substrate supplies to the or-

ganism. /679

Stress induced activation of various enzyme systems that participate in metabolic changes likewise extends to the lipases in the tissue and in the vessels. There is resulting intensification of lipolysis in the adipose tissue, of triglyceride fatty acid hydrolysis and therefore hyperlipacidemia. The raised fatty acid level via a feedback mechnism competitively inhibits glycolysis in the musculature, while there is an intensification of glucose decomposition in the liver and adipose tissue. Moreover insulin secretion is stimulated [9]. Fat metabolism is unaffected. The increase in unsaturated fatty acid concentration may be interpreted as an adaptive emergency reaction to an increased demand for energy-filled substrates. In addition the greater supply of unsaturated compounds results in enhanced membrane peremeability.

It is also supposed [10] that in association with the changes in the fatty acid pattern there is a different lipase effect due to stimulation of catecholamines and fatty acid ester compounds.

In our experiments the relatively unaffected triglyceride fatty acids clearly act as a reserve that depends upon the moment's fatty acid supply and the energy requirements of the organism in various functional states [3].

We are grateful to Mrs. E. Manthey and Mrs. R. Guerke for their carefully planned technical assistance.

REFERENCES

1. Lapin, B. and G. M. Cherkovich in Society, Stress and Disease, Vol. 1, L. Levy, ed., Oxford University Press, London/New York/Toronto, 1971, p. 266.

2. Starzev, V. G., Modelirovaniye nevrogennikh zabolevaniy cheloveka v experimente na obez'yanakh [Modeling of Neurogenic Human Diseases in Monkey Experiments], Meditsina, Moscow, 1971, p. 23.

3. Michailov, M. L., St. Nitschkoff, E. Hollstein and R. Baumann, Die Gesundheitswesen 26, 763 (1971).

4. Duncombe, W. G., Clinica chim. Acta 9, 122 (1964).

5. Baumann, R., H. Ziprian, W. Goedicke, W. Hartrodt, E. Naumann and J. Laeuter, Psychother. Psychosom. 22, 131 (1973).

6. Selye, H., Hormones and Resistance, Part 1, Springer, Berlin/Heidelberg/New York, 1971, p. 531.

7. Pinter, E. J., G. Peterfy, J. M. Cleghorn and C. J. Pattee, Am. J. Med. Sci. 254, 634 (1967).

8. Taggart, P. and M. Carrutheis, Lancet, No. 1, 363 (1971).

9. Crespin, S. R., W. B. Greenough and D. Steinberg, J. Clin. Invest. 48, 1934 (1969).

10. Raulin, J. M. Launay and M. R. Jacquot, C. R. hebd. Séanc. Acad. Sci. (Paris) 259, 223 (1964).